Test Tomorrow!

Circular Motion, Torque, Static Equilibrium, SHM, Satellite Motion

Circular motion:

$$\Sigma \bar{F} = m a_c = \frac{mv^2}{r}$$

Torque:

$$\tau = r F \sin\theta$$

Magnitude

Static Equilibrium:

$$\Sigma \bar{F} = \emptyset$$

$$\Sigma \bar{\tau} = \emptyset$$

SHM:

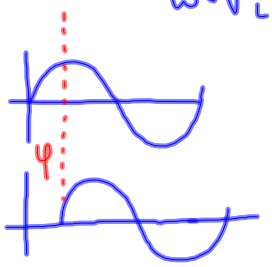
$$x(t) = A\cos(\omega t + \varphi)$$

$$v(t) = -\omega A \sin(\omega t + \varphi)$$

$$a(t) = -\omega^2 A \cos(\omega t + \varphi)$$

for mass/spring $\omega = \sqrt{\frac{k}{m}}$

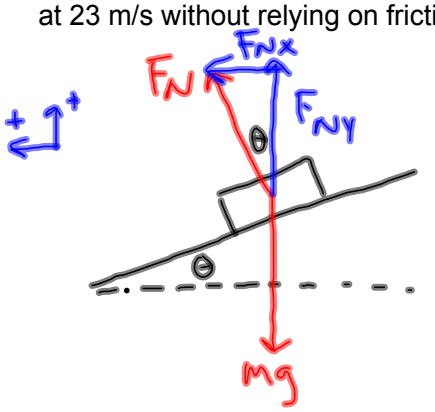
for pendulum $\omega = \sqrt{\frac{g}{L}}$



$T = \frac{1}{f}$ $\omega = 2\pi f$

Satellite Motion: $F = \frac{G m_1 m_2}{r^2}$

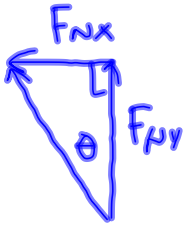
At what angle should a curve of radius 185 m be banked, so that cars can travel safely at 23 m/s without relying on friction?



$$\Sigma F_x = ma_c \qquad \Sigma F_y = 0$$

$$F_{Nx} = \frac{mv^2}{r} \qquad F_{Ny} - mg = 0$$

$$F_{Ny} = mg$$



$$\tan\theta = \frac{F_{Nx}}{F_{Ny}} = \frac{\frac{mv^2}{r}}{mg}$$

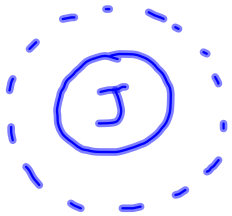
$$\tan\theta = \frac{v^2}{rg}$$

$$\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$$

$$= \tan^{-1}\left[\frac{(23\ m/s)^2}{(185\ m)(9.8\ m/s)}\right]$$

$$= 16.3°$$

A satellite is placed in orbit 2.40E5 m above the surface of Jupiter. Jupiter has a mass of 1.90E27 kg and a radius of 7.14E7 m. Find the orbital speed of the satellite.



$$\Sigma F = \frac{m_s v^2}{r}$$

$$F_G = \frac{m_s v^2}{r}$$

$$\frac{G m_J m_s}{r^2} = \frac{m_s v^2}{r}$$

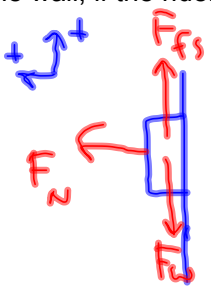
$$v = \sqrt{\frac{G M_J}{r}}$$

r = Combined distances

$$= 41900 \text{ m/s}$$

At amusement parks, there is a popular ride where the floor of a rotating cylindrical room falls away, leaving the backs of the riders "plastered" against the wall. Suppose the radius of the room is 3.25 m and the speed of the wall is 13.0 m/s when the floor falls away.
a) What is the source of the centripetal force acting on the riders?
b) How much centripetal force acts on a 55.0 kg rider?
c) What is the minimum coefficient of static friction that must exist between the rider's back and the wall, if the rider is to remain in place when the floor drops away?

a)



Normal force

b) $F_c = \frac{mv^2}{r}$

$= \frac{(55\ kg)(13\ m/s)^2}{3.25\ m}$

$= 2860\ N$

c) $\Sigma \bar{F}_y = \emptyset$ $\qquad F_{fs} = \mu_s F_N$

$F_{fs} - F_w = \emptyset$

$\mu_s F_N - F_w = \emptyset$

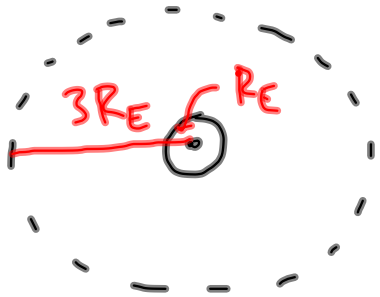
$\mu_s = \frac{mg}{F_N}$

$= .189$

$\Sigma \bar{F}_x = ma_c$

$F_N = \frac{mv^2}{r} = 2860\ N$

A satellite circles the earth in an orbit whose radius is three times the earth's radius. The earth's mass is 5.98E24 kg, and its radius is 6.38E6 m. What is the period of the satellite?



$$V = \frac{d}{T}$$

$$V = \sqrt{\frac{GM_E}{(3R_E)}}$$

$$T = \frac{d}{V} = \frac{2\pi(3R_E)}{\sqrt{\frac{GM_E}{3R_E}}}$$

$$= 26300\ s$$

A spring is hung from the ceiling. A 0.300 kg block is then attached to the free end of the spring. When released from rest, the block drops 0.150 m before momentarily coming to rest.
a) What is the spring constant of the spring?
b) Find the angular frequency of the block's vibrations.

a) 39.2 N/m

b) 11.4 rad/s